OCCLUSION DETECTION FOR FACIAL RECOGNITION PROCESSES

PRIORITY CLAIM

[0001] This patent is a continuation of U.S. patent application Ser. No. 15/934,559 to Gernoth et al., entitled "OCCLUSION DETECTION FOR FACIAL RECOGNITION PROCESSES", filed Mar. 23, 2018, which claims priority to U.S. Provisional Patent Application No. 62/556,407 to Fasel et al., entitled "OCCLUSION DETECTION FOR FACIAL RECOGNITION PROCESSES", filed Sep. 9, 2017 and to U.S. Provisional Patent Application No. 62/556,795 to Fasel et al., entitled "OCCLUSION DETECTION FOR FACIAL RECOGNITION PROCESSES", filed Sep. 11, 2017, each of which are incorporated by reference in their entirety.

BACKGROUND

1. Technical Field

[0002] Embodiments described herein relate to methods and systems for face detection and recognition in images capture by a camera on a device. More particularly, embodiments described herein relate to the detection and assessment of occlusion of facial features in captured images.

2. Description of Related Art

[0003] Biometric authentication processes are being used more frequently to allow users to more readily access their devices without the need for passcode or password authentication. One example of a biometric authentication process is fingerprint authentication using a fingerprint sensor. Facial recognition is another biometric process that may be used for authentication of an authorized user of a device. Facial recognition processes are generally used to identify individuals in an image and/or compare individuals in images to a database of individuals to match the faces of individuals.

[0004] In some cases, an image captured of a user during a facial recognition process (e.g., either an enrollment process or an authentication process) may include at least some occlusion of the user in the image. Occlusion of the user includes the blocking or obscuring of the user (e.g., the face of the user or some portion of the user's face) by some object (e.g., a finger, a hand, hair, masks, scarfs, etc.) in the image. Occlusion of the user in captured images may reduce the effectiveness of processing the image in the facial recognition process.

SUMMARY

[0005] Landmark and occlusion heat maps may be generated and used to assess occlusion of landmarks on a user's face in a captured image. Landmark heat maps may be grid representations of the user's face that are used to estimate the location of landmarks on the user's face in the captured image. The occlusion heat map may be a grid representation of the user's face that includes scaled values representing the amount of occlusion in the regions of the grid. The estimated locations of the landmarks may be used in combination with the occlusion heat map to determine if and how much occlusion of the landmarks there may be in the captured image (e.g., an occlusion score for each of the landmarks). Determined values of occlusion for the landmarks may be used to control one or more operations of the device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Features and advantages of the methods and apparatus of the embodiments described in this disclosure will be more fully appreciated by reference to the following detailed description of presently preferred but nonetheless illustrative embodiments in accordance with the embodiments described in this disclosure when taken in conjunction with the accompanying drawings in which:

[0007] FIG. **1** depicts a representation of an embodiment of a device including a camera.

[0008] FIG. **2** depicts a representation of an embodiment of a camera.

[0009] FIG. **3** depicts a representation of an embodiment of a processor on a device.

[0010] FIG. **4** depicts a flowchart for an embodiment of an occlusion detection process.

[0011] FIG. **5** depicts an example of an embodiment of an image input.

[0012] FIG. **6** depicts a representation of an embodiment of a grayscale image for an example of a landmark heat map.

[0013] FIG. **7** depicts a representation of an embodiment of a grayscale image for an example of an occlusion heat map.

[0014] FIG. **8** depicts a representation of an example of an embodiment of estimated centers of gravity.

[0015] FIG. **9** depicts an occlusion heat map overlaid onto a map of landmark shapes.

[0016] FIG. **10** depicts a block diagram of one embodiment of an exemplary computer system.

[0017] FIG. **11** depicts a block diagram of one embodiment of a computer accessible storage medium.

[0018] While embodiments described in this disclosure may be susceptible to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that the drawings and detailed description thereto are not intended to limit the embodiments to the particular form disclosed, but on the contrary, the intention is to cover all modifications, equivalents and alternatives falling within the spirit and scope of the appended claims. The headings used herein are for organizational purposes only and are not meant to be used to limit the scope of the description. As used throughout this application, the word "may" is used in a permissive sense (i.e., meaning having the potential to), rather than the mandatory sense (i.e., meaning must). Similarly, the words "include", "including", and "includes" mean including, but not limited to.

[0019] Various units, circuits, or other components may be described as "configured to" perform a task or tasks. In such contexts, "configured to" is a broad recitation of structure generally meaning "having circuitry that" performs the task or tasks during operation. As such, the unit/circuit/component can be configured to perform the task even when the unit/circuit/component is not currently on. In general, the circuitry that forms the structure corresponding to "configured to" may include hardware circuits and/or memory storing program instructions executable to implement the operation. The memory can include volatile memory such as static or dynamic random access memory and/or nonvolatile memory such as optical or magnetic disk storage, flash memory, programmable read-only memories, etc. The hardware circuits may include any combination of combinatorial logic circuitry, clocked storage devices such as flops, reg-